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Comparative analysis of some selected macronutrients of soil in orange orchard and degraded forests in Chittagong Hill Tracts, Bangladesh

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Abstract: Status of organic carbon (C), total nitrogen (N), available potassium (K), calcium (Ca) and phosphorus (P) in three different depths (0−5 cm, 5−15 cm and 15−30 cm) on two hill slopes of 35% and 55% in orange orchard cultivated by the *Mro* tribe of Chittagong Hill Tracts (CHTs) were evaluated and compared with those in degraded bush forests, through digging three profiles in each land use. The content of all the five nutrients was found to be higher in the soil of orange orchard than in the soil of forest. But the variation was not consistent for both the slopes. The content varied depth wise also, having the highest value in surface soil in case of both the land uses on both the slopes. A mean available K content was significantly higher in orange orchard than in forest on 55% slope, while it was lower on 35% slope. Surface soil contained the nutrients of K and Ca with the amount of 0.2905-mg·g^{-1} soil and 3.025-mg·g^{-1}soil respectively in the orchard, while 0.1934-mg·g^{-1} soil and 1.6083-mg·g^{-1} soil were respectively in the forest. Organic carbon and total nitrogen were found more or less similar in surface soil on both the land uses showing a slight difference. Available P was found only in orange orchard, and in forest it was too little in amount to detect by the spectrophotometer. The degraded forests were poor in nutrient content due to high rate of soil erosion, which would be possible to be improved by bringing it under tree cover as proved by the adaptation of orange orchard there.

Keywords: Orange orchard; Degraded forests; Soil depth; Slope; Bangladesh

Introduction

In immemorial times, the human beings started their days from the forests and caves of hilly regions. As their population started increasing, the primitive dwellers began to clear forests and hills for their inhabitation and agriculture. Fruit production for human consumption began with the harvesting of wild stands from hills and forests. Today fruits are also cultivated frequently in the hilly and mountainous regions of the world (Gautam *et al*. 2004). Fruits are also found to be grown either wild or cultivated in the hills of Bangladesh. Hills make up one-fifth of the world's landscape and home to at least one-tenth of the world's people (Denniston 1995). High north-south striking hill ranges occupy wholly the district of Chittagong and Chittagong Hill Tracts (CHTs) of Bangladesh representing major hilly region in the country. The CHTs region constitutes 76% of the total hilly region of Bangladesh, of which 90% of the area is hilly, 4% covers villages, rivers and marshes and 6% only suitable for intensive agriculture (Khisa 1997). There are ethnic people in all the 64 districts of Bangladesh; however, they are concentrated in north and northeastern borders, north central region and the entire area of greater CHTs (Khan 1998). Twelve tribes were recorded in the CHTs, of which the *Mro* or *Murung* is the ancient one (Lewin 1869; Roy 1996). Hutchinson (1906) described them as the true aboriginal tribe of the CHTs who has certain peculiar customs that divide them very distinctly from the other tribes.

With the rapid increase of population and limited land resources, many countries throughout the world are facing acute problems of lands for food production. It instigates the people to convert the forestland into agricultural, horticultural and many other kinds of lands. Such activities result in the depletion of the existing forests throughout the world and in Asian countries in particular. The *Mro* tribes who live on the hilltops of deep forests in the CHTs are found to be the consumers of 28 various fruits ranging from the smallest Bethul (*Calamus* spp.) to the gigantic Kanthal (*Artocarpus heterophyllus*), most of which are harbored in the hill forests (Miah *et al*. 2004), where more than 50 species of edible fruit trees were found (Khisa 1998). Moreover, about half (50%) of the rich farmers (annual income Tk. >15000.00) and one-third (30%) of the medium farmers (annual income Tk. 10000.00- Tk. 15000.00) were found to be engaged in horticultural practices, though their primary occupation is fully centered on shifting cultivation (Chowdhury *et al*. 2004). They grow orange in the degraded hills of the CHTs and a drastic change in

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the soil surface was marked with naked eyes as a result of its cultivation. No study was conducted earlier to explore the chemical properties of soil by considering that the rationale of the converting the degraded hills into horticultural orchards would have been possible scientifically in a planned manner. It is hypothesized that such cultivation exerts an impact on the soil environment of the respective microclimatic region. Taking this hypothesis into consideration, chemical analysis of soil in both the orange orchard and degraded hill was carried out to evaluate the status of some selected nutrients there.

Materials and methods

Selection of soil sampling sites

Two paired sites, one on 55% slope and the other on 35% slope, were selected in orange growing area at Thanchi upazilla (sub-district) of Bandarban district at CHTs. In each pair, one part represented orange orchard and the other degraded bushy hill, being adjacently located on similar slope to avoid initial variation in soil properties between the two, due to topographic differences. Soils were sampled from each of the four sites during dry season from the last week of March to first week of April 2005. Soil samples were collected from three profiles in each part at a depth of 0–5 cm (surface soil), 5–15 cm and 15–30 cm. The slope of the sampling sites was determined with the help of Abney's Level.

Soil sample preparation

In the laboratory, collected moist soil samples were first sieved through 10-mm mesh sieve to remove gravel, small stones and coarse roots and then passed through 2-mm mesh sieve. Then the sieved samples were dried in an oven at 105 ºC for eight hours.

Chemical analysis

Soil samples were analyzed chemically to determine organic carbon (C), total nitrogen (N), available potassium (K), calcium (Ca) and phosphorus (P) by conventional methods of soil chemical analysis. The data were then analyzed statistically and arranged systematically.

Results and discussion

Organic carbon (C)

Organic carbon contents in both the land uses are shown in Table 1. Orange orchard contained higher mean soil organic carbon than degraded forest on both the slopes. The highest value of organic carbon was found at surface soil on both land uses, which decreased as the soil depth increased. On 55% slope, the values of organic carbon at surface soil were the same in both the land uses. But on 35% slope its value at surface soil was slightly higher in degraded forest than in orchard.

Jamali (1992) reported the similar trend of increase in organic carbon contents of the surface soil. He found increase in organic carbon content at surface soil from 1.10% to 1.14% and 0.69% to 0.72% under Akashmoni (*Accacia auriculiformis*) and Garjan (*Dippterocarpus turbinatus*) plantations, respectively. Osman *et al.* (2002) found contents of this element in the 0-15 cm soil depth from 0.53% to 0.63%, 0.45% to 0.59% and 0.31% to 0.55% under *Accacia auriculiformis, A. mangium and Dipterocarpus costatus* plantations of Chittagong and Cox's Bazar Forest Divisions, Bangladesh.

The organic carbon contents varied with depth within land uses on both the slopes. On 55% slope, there was significant difference in organic carbon between the depth of 0–5 cm and the depth of 5–15 cm as well as 0-5cm and 15-30 cm depths. On 35% slope, significant difference was found in organic carbon contents at two depths of 0–5 cm and 15–30 cm.

Total nitrogen (N)

Table 2 shows total nitrogen concentrations in soil of the study land uses. Total nitrogen content (%) was slightly higher or similar in orchard compared to degraded forest in all the depths. Surface soil of orange orchard contained 0.16% to 0.18% and forest soil contained 0.14% to 0.17% total nitrogen.

Table 1. Organic carbon (%) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Land use	
		Orange Orchard	Forest
55	0–5	2.12 ± 0.10*	2.12 ± 0.68
	5–15	1.83 ± 0.12	1.76 ± 0.73
	15–30	1.70 ± 0.05*	1.57 ± 0.39
	Mean	1.88	1.82
35	0–5	2.35 ± 0.31	2.38 ± 0.32
	5–15	2.22 ± 0.17	2.12 ± 0.20
	15–30	2.02 ± 0.09*	1.89 ± 0.20
	Mean	2.20	2.13

Notes: Each value is the mean of three replicated samples; *----The values are significant ($P \leq 0.05$).

Mean value of total nitrogen of all the depths was higher in orange orchard than in degraded forest on both slopes, but the differences was not significant, at 5% level. The values of total nitrogen varied depth wise in both land uses. The values were higher in all the depths in orange orchard than in forest on 55% slope. But on 35% slope, the values were lower in all the depths in orange orchard compared to forest except in 15–30 cm depth. The values of total nitrogen were generally lower in the studied land uses, which also supported by Soil Resource Development Institute (SRDI) of Bangladesh (2002).

Table 2. Total nitrogen (N) (%) at three different soil depths on 55% slope and 35% slopes in orange orchard and forest.

Slope (%)	Soil depth (cm)	Land use	
		Orange Orchard	Forest
55	0–5	0.18 ± 0.04	0.14 ± 0.04
	5–15	0.19 ± 0.05	0.17 ± 0.06
	15–30	0.20 ± 0.04	0.16 ± 0.03
	Mean	0.19	1.82
35	0–5	0.16± 0.03	0.17 ± 0.03
	5–15	0.21 ± 0.01	0.22 ± 0.06
	15–30	0.26 ± 0.01	0.23 ± 0.05
	Mean	0.21	0.20

Notes: Each value is the mean of three replicated samples.

It has been evident from the study that tree covers play important role on nitrogen status in soil and has been reported to increase total nitrogen of surface soil through decomposition of litter. Jamali (1992) also revealed that due to litter decomposition total nitrogen content increased from 0.11% to 0.12% under Akashmoni (*Acacia auriculiformis*) and 0.06% to 0.07% under Garjan (*Dipterocarpus turbinatus*) plantations.

Available potassium (K)

On 55% slope, the value of available K at surface soil was higher in orange orchard in comparison to forest, not showing significant difference. But the values were significantly higher ($p \leq 0.05$) in 5−15-cm and 15−30-cm soil depths in orange orchard compared to forest (Table 3).

Table 3. Available potassium (mg/g soil) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Land use: Orange orchard	Land use: Forest
55	0–5	0.2592 ± 0.1101	0.1267 ± 0.0614
	5–15	0.1750 ± 0.0325*	0.0775 ± 0.0336
	15–30	0.1408 ± 0.0088*	0.07 ± 0.0175
	Mean	0.1917*	0.0914
35	0–5	0.3217 ± 0.0813	0.26 ± 0.1038
	5–15	0.1883 ± 0.0871	0.2067 ± 0.1215
	15–30	0.1892 ± 0.0617	0.2383 ± 0.199
	Mean	0.2331	0.235
Mean of both slopes	0–5	0.2905	0.1934

Notes: Each value is the mean of three replicated samples; *---- The values are significant ($p \leq 0.05$).

On 35% slope, the value of available K at surface soil was higher in orange orchard than in forest. Conversely, the values in 5−15 cm and 15−30 cm soil depths were lower in orange orchard compared to forest. Mean available K contents were significantly higher in orange orchard than in forest on 55% slope. The mean value was lower in orange orchard than in forest on 35% slope.
Irrespective of soil depth and hill slope, the values of available K ranged from 0.1408 to 0.3217 $mg \cdot g^{-1}$ soil in orange orchard, while from .07 to 0.26 $mg \cdot g^{-1}$ soil in forest. The highest value of available K (0.3217 $mg \cdot g^{-1}$ soil) was found at surface soil in orange orchard on 35% slope.

Similar findings were also reported by other researchers. Hossain and Chowdhury (1984) found that available potassium contents were 0.1546, 0.1243, 0.2003 and 0.0917-$mg \cdot g^{-1}$ soil under 32, 22, 12 and 5 years old teak plantation, respectively at Ichamati Forest Beat, Chittagong, Bangladesh. Available potassium in 0−15 cm soil depth ranged from 0.0117 to 0.0234, 0.0158 to 0.0245 and 0.0190 to 0.0278-$mg \cdot g^{-1}$ soil under 4.5 to 11.5 years old *Acacia auriculiformis*, 3.5 to 8.5 years old *A. mangium* and 26.5-year-old *Dipterocarpus costatus*, respectively in Bangladesh (Osman *et al.* 2002).

Available calcium (Ca)

On both the slopes the values of available Ca in all soil depths were higher in orange orchard compared to forest (Table 4). In both the land uses, the highest value of available Ca was found at surface soil and the value decreased with the increase of soil depth with a few exceptions and this result is consistent with the result of Osman *et al.* (2002). But on 35% slope, the value increased at soil depth in 15−30 cm in both the land uses. On 55% slope, the values of available Ca were the same in 5−15 cm and 15−30 cm of soil depths in forest. The values were also the same at 0−5 cm and 15−30 cm on 35% slope in forest. Irrespective of soil depth and slope, the values of available Ca ranged from 1.6 to 3.1667 mg/g soil in orange orchard and 0.9 to 2.1333 $mg \cdot g^{-1}$ soils in forest.

Available phosphorus (P)

On both the slopes between two land uses, available P was found only in orange orchard (Table 5). In forest P was so few in amount that it was unable to detect by the spectrophotometer. This result suggests that the rate of soil erosion should be higher in forest than in orange orchard that significantly lowered the nutrient rich surface soil, and in effect, the amount of available P decreased.

Table 4. Available calcium (mg/g soil) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Land use: Orange orchard	Land use: Forest
55	0–5	2.8833 ± 0.7489	1.0833 ± 0.3786
	5–15	1.9667 ± 0.4509	0.9 ± 0.1803
	15–30	1.6 ± 0.1732	0.9 ± 0.1
	Mean	2.15	0.9611
35	0–5	3.1667 ± 1.0774	2.1333 ± 0.8751
	5–15	181.67 ± 72.51	1.7333 ± 0.9224
	15–30	2.2167 ± 0.3329	2.1333 ± 1.6616
	Mean	2.4	2.0
Mean of both slopes	0–5	3.025	1.6083

Notes: Each value is the mean of three replicated samples.

Table 5. Available phosphorus (mg/g soil) at three different soil depths on 55% and 35% slopes in orange orchard and forest

Slope (%)	Soil depth (cm)	Land use: Orange orchard	Land use: Forest
55	0–5	0.025 ± 0.016	-
	5–15	0.0060 ± 0.0009	-
	15–30	0.0073 ± 0.0020	-
	Mean	.0128	-
35	0–5	0.0761 ± 0.0106	-
	5–15	0.03 ± 0.0055	-
	15–30	0.0219 ± 0.0094	-
	Mean	0.0427	-

Notes: Each value is the mean of three replicated samples.

On both the slopes, the highest value of available P was found at surface soil in orange orchard, which decreased with the soil depth except in 15−30-cm depth on 55% slope where the value increased with soil depth. The highest value of available P was found 0.0761 mg/g-soil at surface soil in orchard on 35% slope. This result may be due to the lower hill slope allowing less soil erosion than the higher hill slope. The scarcity of available P in the forests of the studied area was also reported by Soil Resource Development Institute (SRDI) of Bangladesh (2002), where they

described the availability of P as low to very low in the forest soil of the studied area.

It was observed that the degraded hills, after being converted into orange orchard, were subjected to more or less intensive management by the formers. The owners of the orchard were reported to apply occasionally organic manure, particularly cow-dung and poultry fasces; to check surface erosion by placing banana trunk across the slope; to mulch the orchard floor with weeds and bushes. Such operations are thought to be the reasons behind the orange orchards' having the nutrient contents in higher proportion other than the depleted forests. Due to the tree cover, the orchard floor is also prevented from wind erosion compared to the bare forestlands. It also facilitates the orange orchard to contain much more nutrients in the surface soil.

Conclusions

The property of soil regarding the content of five nutrients viz., organic C, total N, available K, Ca and P in the degraded hill forests of the CHTs was increased after converting them into horticulture with the cultivation of orange. The *Mro* tribe grows there orange as secondary occupation though their primary occupation is fully centered on shifting cultivation. In the present study, the impact of orange cultivation on limited chemical characteristics of existing hill forest soils was explored. Further study needs to carry out on the impact of orange cultivation on other chemical, physical and biological properties of the soil of that area. It would be helpful for policy makers to decide whether to cultivate orange and/or other fruits in the degraded hills of CHTs to uplift the socio-economic conditions and living standard of the hill dwellers, particularly the *Mro*, the most undeveloped tribe of Bangladesh on the one hand and to improve the soil condition of the exhausted forests on the other hand.

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